May 17, 1960 J. J. LOGAN 2,937,296

SPARK DISCHARGE DEVICE

Filed Feb. 12, 1959 2 Sheets-Sheet 1

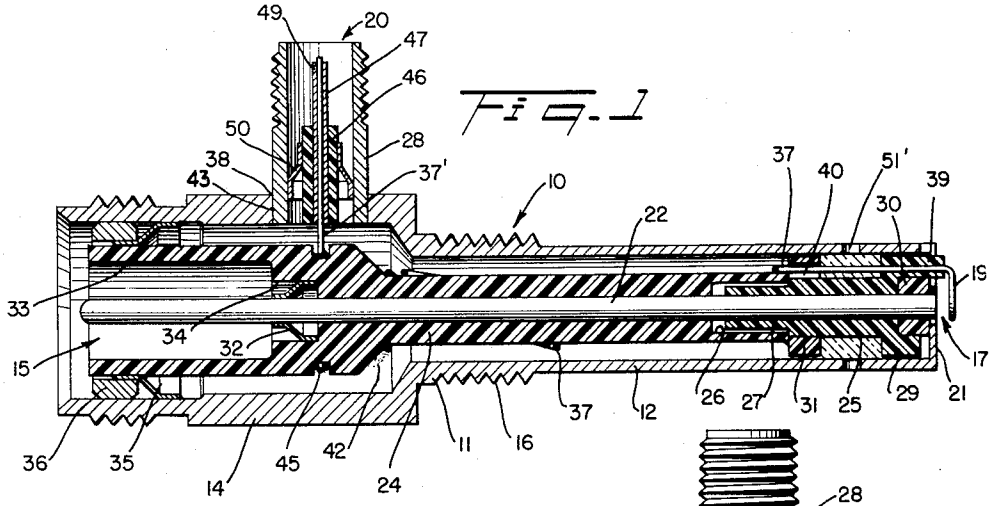


Fig. 1

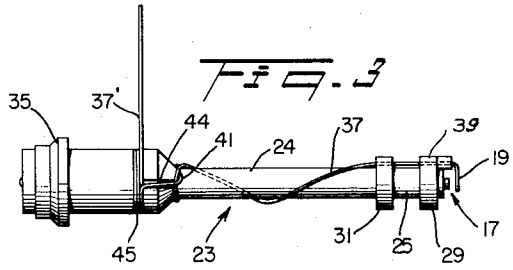


Fig. 3

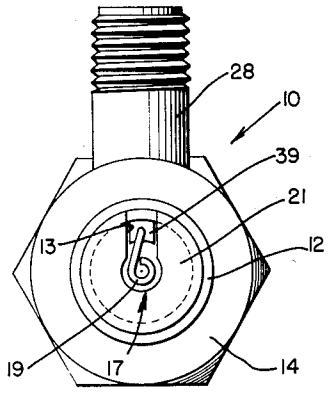


Fig. 2

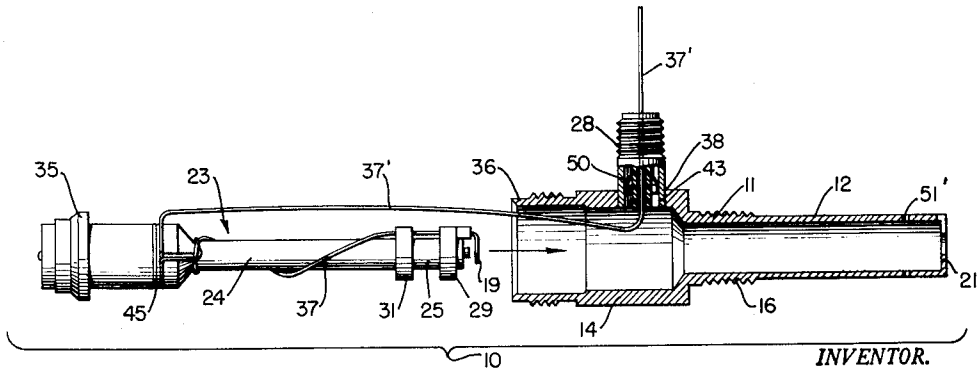


Fig. 4

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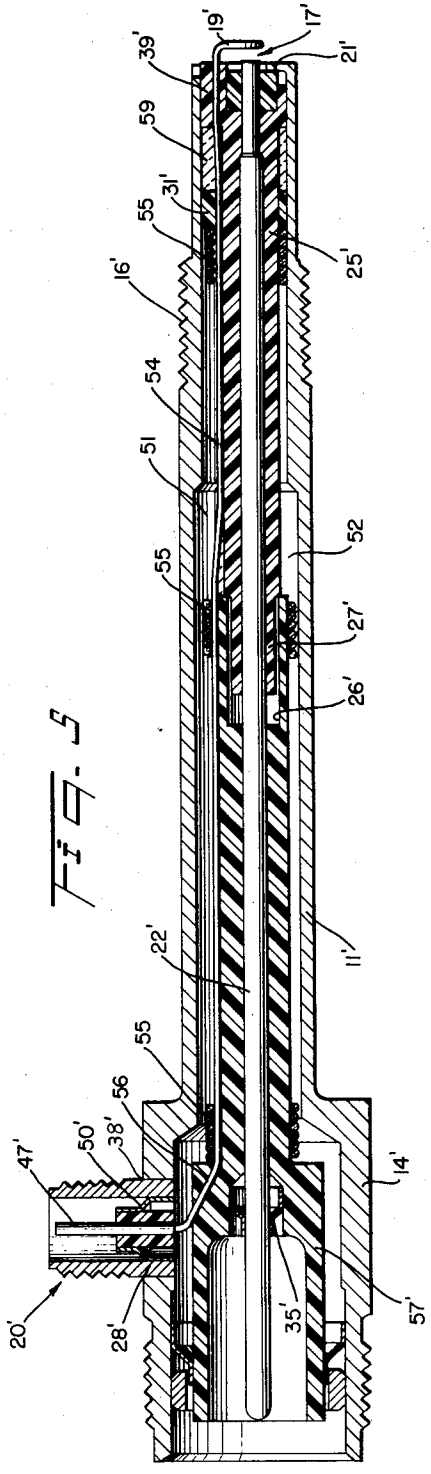


FIG. 5

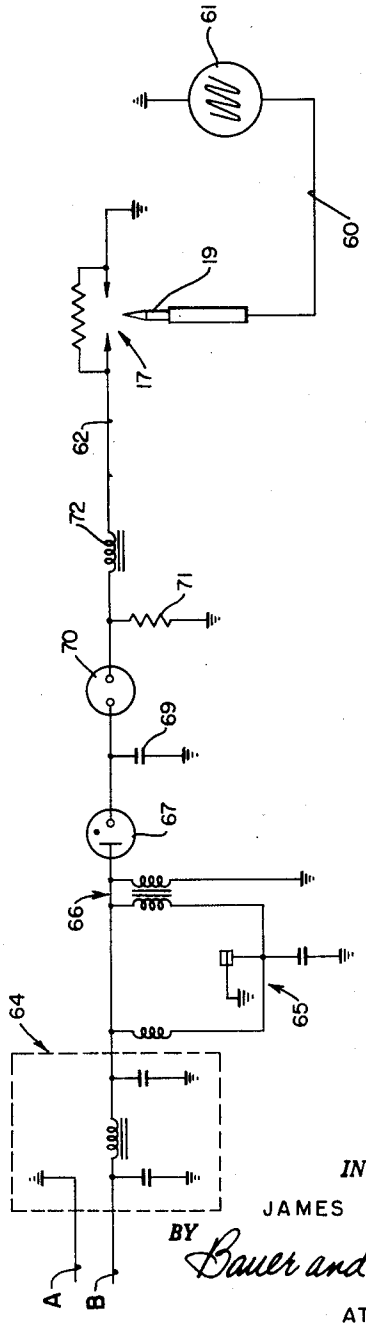


FIG. 6

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SPARK DISCHARGE DEVICE

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22 Claims. (Cl. 313—51)

This invention relates to a spark discharge device, and more particularly to a spark discharge device having a monitoring or detecting means thereon to afford an indication when the discharge device is functioning correctly.

The invention has among its objects the provision of a novel spark discharge device with spark monitoring means.

A further object of the invention lies in the provision, in a spark discharge device of the type indicated, of novel improved means for mounting the detecting probe of the spark monitoring means.

Yet another object of the invention lies in the provision of improved means for locating an electrical lead wire, extending from the probe to an output terminal on the device, spaced and electrically isolated from the metallic shell of the device.

Yet a further object of the invention lies in the provision of an improved terminal for the output lead from the probe, and novel improved means for effecting a seal between such terminal and the shell of the device.

The above and further objects and novel features of the invention will more fully appear from the following description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not intended as a definition of the limits of the invention.

In the drawings, wherein like reference characters refer to like parts throughout the several views—

Fig. 1 is a view in longitudinal axial section through a spark discharge device with spark monitoring means made in accordance with a first embodiment of the inventon, certain of the parts being shown in elevation;

Fig. 2 is a view in end elevation of the spark discharge device of Fig. 1, the view being taken in the direction from right to left in Fig. 1;

Fig. 3 is a view in side elevation on a reduced scale of the internal sub-assembly of the device of Fig. 1;

Fig. 4 is an exploded view, partially in longitudinal section of the spark discharge device shown in Fig. 1.

Fig. 5 is a view in longitudinal axial section through a second embodiment of spark discharge device made in accordance with the invention; and

Fig. 6 is a schematic wiring diagram of an ignition circuit incorporating the spark discharge device of the invention.

The spark discharge device with spark monitoring means of the present invention allows the presence or absence of sparks across the spark gap of the device to be detected by suitable means located externally of the engine or the like in which the spark discharge device is mounted. The spark discharge device of the invention has proved to be particularly useful, although it is obviously not limited to such applications, in initiating combustion in the combustion chamber of a missile, rocket, or the like. With such mechanisms it is customary first to energize the spark discharge device and then to allow

fuel to flow into the combustion chamber. Should the spark device not function properly, there is great danger of an explosion if the chamber should become unduly filled with fuel. In such applications, use of the spark monitor in the device of the invention informs the operating personnel when the spark discharge device is working satisfactorily, and thus whether or not it is safe to begin the introduction of fuel into the chamber.

In its use in the combustion chamber of a missile, rocket or the like, a spark discharge device and the monitoring means therefor are subjected to arduous conditions. Not only is the device subjected to high temperature, but it must also withstand relatively high pressures which may reach values on the order of 1000 pounds per square inch. Additionally, the device is subjected to marked vibration which tends to cause it to fail mechanically. For these reasons, the provision of a satisfactory spark monitoring probe in combination with a spark discharge device, particularly within the space limitations imposed, is difficult.

The spark discharge device of the present invention incorporates therein a spark monitoring probe, the spark discharge device and probe being so constructed as to withstand long service under the conditions above outlined, and to present a seal between the combustion chamber and the output lead of the probe, as well as between the chamber and the power source for the discharge electrodes. The device also provides a novel, simple, and effective manner of maintaining the electrical lead from the probe electrically isolated from the shell of the device, such manner of mounting the lead wire also facilitating the assembly of the device. The construction of the device is such that, in preferred embodiments thereof, the presence of the monitoring probe, its lead wire, and terminal, adds very little to the over-all dimensions of a conventional spark discharge device without a probe means.

The spark discharge device of the invention incorporates therein two spaced electrodes across which, when they are energized by a suitable high tension source, there is formed a spark discharge. The device also incorporates a spark monitoring probe, the inner end of which extends close to spark gap so as to detect the presence or absence of a spark discharge thereacross. In the embodiment illustrated in Fig. 6 herein, the monitor probe is connected to an oscilloscope, which indicates voltage variations in the monitoring circuit including the monitoring probe, such monitoring circuit, in effect, functioning as a voltage divider at the gap, the probe deriving its voltage from the spark discharge through the ionized gas in the vicinity of the spark discharge. It is to be understood that the monitoring probe does not enter into the formation of the spark discharge, and that the current flow from the spark discharge to the monitoring probe is of relatively small amperage.

Turning now to the drawings, there is shown in Figs. 1 and 2 a spark discharge device **10** with spark monitoring means made in accordance with the invention. Such device has an outer elongated metal shell **11** having an elongated forward cylindrical portion **12** of smaller diameter and a rear cylindrical portion **14** of somewhat larger diameter. The rear end of portion **14** is provided with means functioning as one part of a separable electrical connector, the outer end of central electrode **22** serving as the central contact pin of such connector. Within the shell **11** there is positioned an elongated insulator **24** having a single forward cylindrical portion and a larger rear portion joined by a frusto-conical shoulder **42**, the forward and rear portions of the insulator being of appreciably smaller diameter than the portions of the shell **11** within which they lie, whereby to present annular spaces of appreciable radial depth therebetween.

The main central insulator 24 conveniently has a separate forward portion 25 which is attached thereto by having an elongated central boss 27 on insulator 25 received within a central recess 26 on the forward end of insulator 24.

Insulator 25 has an enlarged annular forward end 29 which snugly fits within portion 12 of the shell 11, and thus centers the central insulator. The spark discharge device shown is of the shunted gap type. Insulator 25 is accordingly employed also to mount an annular semiconductive ceramic insert 30 which surrounds the forward end of central electrode 22 and is thrust against the rear surface of flange 21 so as to be connected in shunt between the electrodes. Immediately forward of the end of insulator 24, insulator 25 carries a ceramic washer 31 which further serves to center insulators 24 and 25 in shell 11, and also aids in supporting the probe electrode.

The larger, rear end of insulator 24 is provided with a central recess 33 into which the rear, contact-pin providing end of electrode 22 extends. Located within a smaller central recess 34 at the forward end of recess 33 is a flexible metal diaphragm 32 which is brazed at its rear smaller end to electrode 22 and at its forward larger end to the metallized wall of recess 34. The sealing of the outer end of the main portion of the device is completed by a flexible metal diaphragm 35 having a larger forward end brazed to the inner wall of shell portion 14 and its smaller rear end brazed to the metallized peripheral surface of insulator 24. A retainer ring 36, fitting between the wall of portion 14 of the shell and the rear end of the diaphragm 35, is brazed to both.

The probe electrode is generally L-shaped. The outer or second leg 19 of such electrode preferably has its end bent into a circle generally coaxial with electrode 22 so as to provide an electrode having appreciable operative area overlying the spark gap. The other or first leg of the probe electrode extends parallel to the axis of shell 11 and is mounted in a passage in a portion 39 of insulator 25 which has a forward end extending through a slot 13 in flange 21. The rear end on the first leg of the probe electrode extends through a slot 40 in ceramic washer 31. The lead wire from the probe electrode, which preferably is an extension of the wire from which the probe electrode is made and is uninsulated, is generally designated 37. In the embodiment shown wire 37 extends rearwardly in one complete turn about insulator 24, is secured by half-hitch 41 at the juncture of shoulder 42 with the forward smaller diameter portion of insulator 24, and thence extends rearwardly in slot 44 parallel with the axis of insulator 24. Somewhat rearwardly of shoulder 42 insulator 24 is provided with a peripherally extending groove 45. Wire 37 is wrapped several times within groove 45 and is then led off in a straight run 37' which extends to connector part 20.

Connector part 20 has a tubular housing or shell 28, a radially inner end of which extends within a radial passage 43 in shell 14 and is welded to the shell at an annular zone 38. A ceramic insulating sleeve 46 is attached and sealed to shell 28 by a diaphragm 50 having its outer larger end brazed to the shell and its inner smaller end brazed to the metallized periphery of sleeve 46. Sleeve 46 has a central bore the surface of which is metallized. A metallic tube 47 made, for example, of an iron nickel alloy such as that known as "Kovar," snugly fits within, and is brazed to the inner surface of, sleeve 46. In the assembled device, lead wire 37' extends outwardly through tube 47 and is brazed thereto at zone 49 at the outer end of the tube.

In assembling the device, the mating surfaces of recess 26 in insulator 24 and boss 27 on insulator 25 are coated with a refractory cement such as that known as "Sauereisen," the inner periphery of washer 31 is coated with a similar cement, and the members are assembled as

shown. Refractory insert 30 is then mounted in the forward recess in insulator 25, being held therein by a suitable refractory cement. A wire 37 is then inserted through the passage and slot in refractory members 39 and 31, respectively, the forward end of the wire being then bent into the shape of probe electrode 19. Wire 37 rearwardly of the electrode is disposed as shown in Fig. 3 and described above.

The final assembly operation is schematically indicated in Fig. 4. The housing 28 is first welded to shell 11. The tube 47, ceramic insulator 46, and diaphragm 50, prepared as above described, are next assembled, placed within housing 28, and all such parts are brazed together. The sub-assembly 23 is now mounted in shell 11. As shown in Fig. 4, a sufficient length of lead wire 37' is left on sub-assembly 23 so that when the wire is bent forwardly its forward end may readily be snaked through tube 47. Assembly 23 is now advanced into the shell, tension being maintained upon the forward end of lead wire 37' so as to prevent the formation of kinks in the wire. When assembly 23 has been fully advanced into the shell lead wire 37' will extend radially from tube 47. Wire 37' is now cut off flush with the outer end of tube 47, and is brazed thereto. Following this, the annular space between washer 31 and the forward portion of shell 11 and between such shell and insulator 24 is filled with a refractory cement, such as "Sauereisen" cement, through holes 51' in shell 11. A ring of a suitable brazing metal is disposed in the rear end of shell 11 rearwardly of diaphragm 35, and retainer ring 36 is then telescoped over the insulator 24 and within the rear end of the shell 11.

The assembly is then charged into a suitable furnace, and is heated to braze diaphragm 35 to the shell and ring 36 to the diaphragm. Such heating also serves to cure the cement between insulator 24 and the forward end of shell 11.

In Fig. 5 there is illustrated a second embodiment of spark discharge device made in accordance with the invention. In such figure, parts of the device which are similar to those of the device of Figs. 1–4, inclusive, but for changes of proportion are designated by the same reference characters with an added prime.

The device of Fig. 5 differs from that of Figs. 1–4, inclusive, aside from such differences in proportion, in the construction of the means maintaining the probe electrode lead electrically isolated from the shell 11' and firmly secured to insulator 24', the means securing the probe lead in the run thereof radially inwardly of the probe outlet terminal, and the manner in which the insulator 24' is sealed to shell 11'.

In the embodiment of Fig. 5, the elongated body of insulator 24' is so shaped and disposed relative to shell 11' that the annular space between the insulator and shell is appreciably radially larger on one side, as shown at 51, than it is on the opposite side, as shown at 52. The enlarged end portion 39' of insulator 24', through which the second leg of the probe electrode extends, is disposed in alignment with said larger space 51, so that the lead wire 54 from the probe electrode extends generally in a straight line from the end of the second leg of the electrode and along the surface of insulator 24' in space 51 toward the probe electrode outlet 20'.

The lead wire 54 is held firmly in position on insulator 24' by wrappings or servings 55 of heat-resistant cord or the like which are tightly wound around the insulator and lead wire at locations spaced longitudinally of the insulator. Cord made of heat-resistant glass fibers may advantageously be employed for making servings 55.

The lead wire 54, in this embodiment, extends through an outwardly and rearwardly directed passage 56 in the outer, larger end of insulator 24', the passage being located in the plane of lead wire 54 and of tube 47' and hav-

ing its outer rear end lying adjacent the radially inner end of tube 47'.

Sealing between the inner end of insulator 24' and shell 11' is effected by a washer 59 which is telescoped over the forward end of insulator 24' and lead wire 54, and is slid with the inner assembly of insulator, the central discharge electrode, monitoring or probe electrode, etc., into shell 11. Washer 59 is made of a heat softenable material such as glass which bonds to the shell, the insulator, and the lead wire upon its being heated to moderately high temperature. A suitable material for washer 59 is a lead oxide glass having a vitrifying temperature of 1800–1900° F. When the washer 59 is made of such material, the described seal is made, after the device has been assembled, by heating the shell 11' locally as with a torch applied to the outer surface thereof. The thus formed seal provides an effective barrier against the penetration of fuel past the seal and into the interior of the device.

The spark discharge device of the invention may be energized by a more or less conventional circuit such as shown in Fig. 6. As there shown, such circuit includes a radio-interference filter 64, which is connected to a suitable source of direct current through leads A and B. Beyond the filter, the circuit includes a vibrator 65, which periodically interrupts the current in the primary of a transformer 66. The secondary of the transformer feeds into a series circuit having a rectifier 67, a control gap 70, and an inductance coil 72. A storage condenser 69 is connected on one side between the rectifier and the control gap and on the other side to ground. A bleed resistor 71 is connected on one end between the control gap and the inductance coil, and on the other end to ground. The delivery end of the inductance coil is connected by lead wire 62 to the central electrode of spark gap 17. The other, outer electrode of such gap is connected to ground.

The monitoring probe 19 is connected by wire 60 to one side of an oscilloscope 61. The other side or terminal of the oscilloscope is connected to ground.

When a spark discharge occurs across gap 17, the gas in the vicinity of the gap is ionized. The probe 19 is then raised in voltage by reason of such ionization; the oscilloscope connected to the probe visually indicates voltage variations in the probe, and thus affords an indication of the functioning of the spark gap.

Although only a limited number of embodiments of the invention have been illustrated in the accompanying drawings and described in the foregoing specification, it is to be expressly understood that various changes, such as in the relative dimensions of the parts, materials used, and the like, as well as the suggested manner of use of the apparatus of the invention, may be made therein without departing from the spirit and scope of the invention as will now be apparent to those skilled in the art. Thus, for example, the monitoring probe, rather than being connected to an oscilloscope, to detect voltage variations in the probe circuit, may be connected in series with a suitable source of direct current such as a battery, a milliammeter, and ground. In such system the battery discharges through the ionized gas accompanying a spark discharge, whereby the milliammeter affords an indication of the functioning of the spark discharge device.

What is claimed is:

1. In a spark discharge device having an elongated metal shell, an elongated insulator extending longitudinally of the shell, a longitudinally extending conductor in the insulator, and a spark gap between the conductor as a first electrode and the shell as a second electrode at the second, forward end of the device, the improvement which comprises monitor means for detecting spark discharges between the electrodes at said gap, said monitor means comprising a monitoring probe electrode overlying and spaced from the spark discharge gap, electrically insulating means mounting the probe electrode on the device, a terminal means on the shell and insulated therefrom adjacent the rear end thereof, a contact in said terminal means, and an electrical lead electrically isolated from the shell extending from the probe electrode in a rearward direction within the shell to the contact of said terminal means.

2. A spark discharge device as claimed in claim 1, wherein the terminal means comprises a housing connected to and having its interior communicating with the interior of the shell, and a contact connected to the electrical lead mounted within and spaced from and insulated from the housing.

3. A spark discharge device as claimed in claim 2, comprising means for sealing the contact to the housing.

4. A spark discharge device as claimed in claim 3, wherein the contact comprises a tube extending axially of the housing, and the electrical lead at the terminal is a wire extending into the tube and sealed thereto.

5. A spark discharge device as claimed in claim 4, wherein the wire fits snugly within the tube, extends outwardly therethrough to the outer end of the tube, and is bonded thereto by fused metal at the outer end of the tube.

6. A spark discharge device as claimed in claim 2, wherein the housing extends generally normal to the length of the shell, the insulator extends within the shell and is radially spaced therefrom at the inner end of the housing, the electrical lead is a wire, and the wire extends from the outer surface of the insulator directly to the contact of the terminal means.

7. A spark discharge device as claimed in claim 6, wherein the insulator is provided with a wire-retaining means located inwardly of the contact, and the wire extends substantially directly from the wire-retaining means to the contact.

8. A spark discharge device as claimed in claim 7, wherein the insulator is provided with a peripheral groove generally aligned with the contact transversely of the shell, the wire extends along the insulator from the probe electrode to the contact, and the wire is wrapped around the insulator in the groove and then extends to the terminal.

9. A spark discharge device as claimed in claim 8, wherein the wire extends substantially in a straight line tangentially from the groove in the insulator to the terminal.

10. A spark discharge device as claimed in claim 8, wherein the insulator is of markedly less diameter than the shell, the wire extends along the outer surface of the insulator spaced from the shell, and comprising means for maintaining the wire against the insulator and spaced from the shell.

11. A spark discharge device as claimed in claim 10, wherein the wire is maintained substantially taut between the probe electrode and the terminal, and the wire is coiled about the insulator in a steep helix from rearwardly of the probe electrode to forwardly of the groove in the insulator.

12. A spark discharge device as claimed in claim 11, wherein the insulator is of markedly greater diameter at the rear portion thereof confronting the housing than at its intermediate and forward portions, there is a forwardly converging frusto-conical shoulder joining the rear and intermediate portions of the insulator, and there is a knot in the wire overlying the smaller end of the shoulder.

13. A spark discharge device as claimed in claim 7, wherein the wire extends in a substantially straight line along one side of the insulator from the probe electrode toward the contact of the said terminal means.

14. A spark discharge device as claimed in claim 13, wherein the insulator has the forward end thereof eccentric relative to the confronting inner surface of the

shell, and the lead wire extends within the larger zone of the space between the forward portion of the insulator and the shell.

15. A spark discharge device as claimed in claim 14, comprising at least one serving about the insulator and the wire to secure the wire to the insulator.

16. A spark discharge device as claimed in claim 15, wherein the rear portion of the insulator is of larger diameter than the forward portion thereof, there is an outwardly and rearwardly directed passage in the larger portion of the insulator in the plane of the wire and the contact, and the rear portion of the wire extends through said passage and thence to the contact.

17. In a spark discharge device having an elongated metal shell, an elongated insulator extending longitudinally of the shell, a longitudinaly extending conductor in the insulator, and a spark gap between the conductor as a first electrode and the shell as a second electrode at the second, forward end of the device, the improvement which comprises monitor means for detecting spark discharges between the electrodes at said gap, means on the insulator for mounting the probe electrode, the insulator throughout an appreciable portion of its lentgh rearwardly of the gap having a diameter substantially less than, and spaced appreciably from, the inner wall of the shell, an annular enlargement on the forward end of the insulator, the probe being generaly L-shaped, one leg of the probe extending through and being secured to the enlargement, the other leg of the probe overlying the spark gap, a terminal means on the shell and insulated therefrom adjacent the rear end thereof, a contact in said terminal means, and an electrical lead electrically isolated from the shell extending from the probe electrode in a rearward direction in the space between the shell and the insulator to the contact of said terminal means.

18. A spark discharge device as claimed in claim 17, wherein the forward end of the shell is radially inwardly flanged, the radially inner portion of the flange constitutes said second electrode, said flange has a passage therethrough offset from its axis, the enlargement on the insulator has a forwardly extending hollow projection, said projection extends forwardly through said passage, and the first leg of the probe electrode extends through the projection.

19. A spark discharge device as claimed in claim 17, comprising a second annular enlargement on the insulator rearwardly of the first recited enlargement, the second enlargement having a passage therethrough receiving the first leg of the probe electrode, and means securing the first leg of the probe electrode to the insulator and its enlargements.

20. A spark discharge device as claimed in claim 17, wherein the wall of the shell is impervious, and comprising means sealing the insulator to the shell adjacent the forward end thereof.

21. A spark discharge device as claimed in claim 20, wherein the sealing means comprises an annular sealing member having a fused bond to the shell, the insulator, and the wire.

22. A spark discharge device as claimed in claim 17, wherein the leg of the probe element which overlies the spark discharge gap is generally annular and lies generaly parallel to such discharge gap.

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Notice of Adverse Decision in Interference

In Interference No. 93,825 involving Patent No. 2,937,296, J. J. Logan, SPARK DISCHARGE DEVICE, final judgment adverse to the patentee was rendered May 26, 1966, as to claim 1.

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